Hydrologic and Water Quality Monitoring on Turkey Creek Watershed, Francis Marion National Forest, SC

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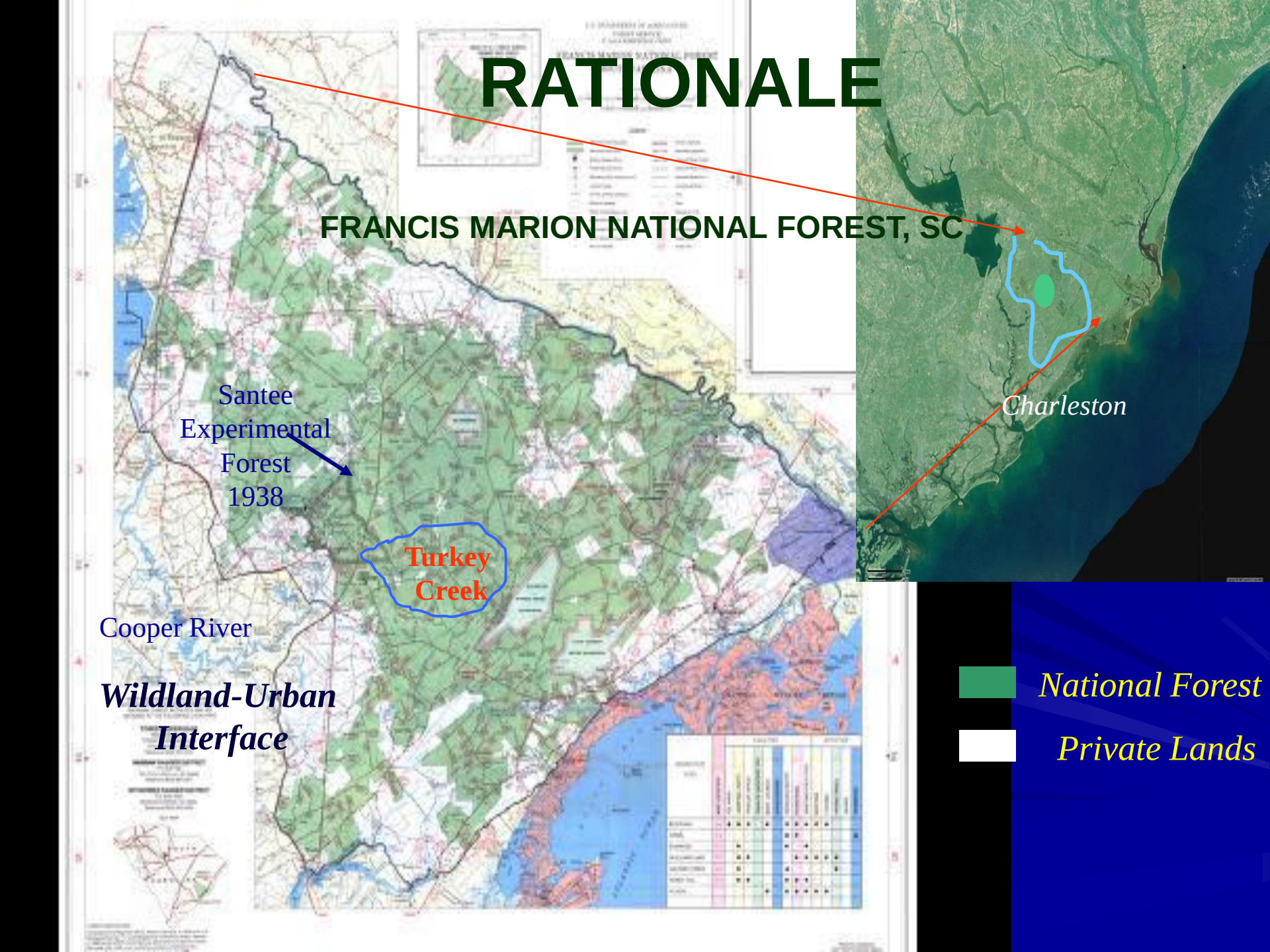
A South Carolina Water Resources Conference Presentation
October 15, 2008, North Charleston, SC

RATIONALE


FRANCIS MARION NATIONAL FOREST, SC
Santee
Experimental
Forest
1938
Turkey
Creek
Cooper River
Wildland-Urban
Interface
Charleston
National Forest
Private Lands

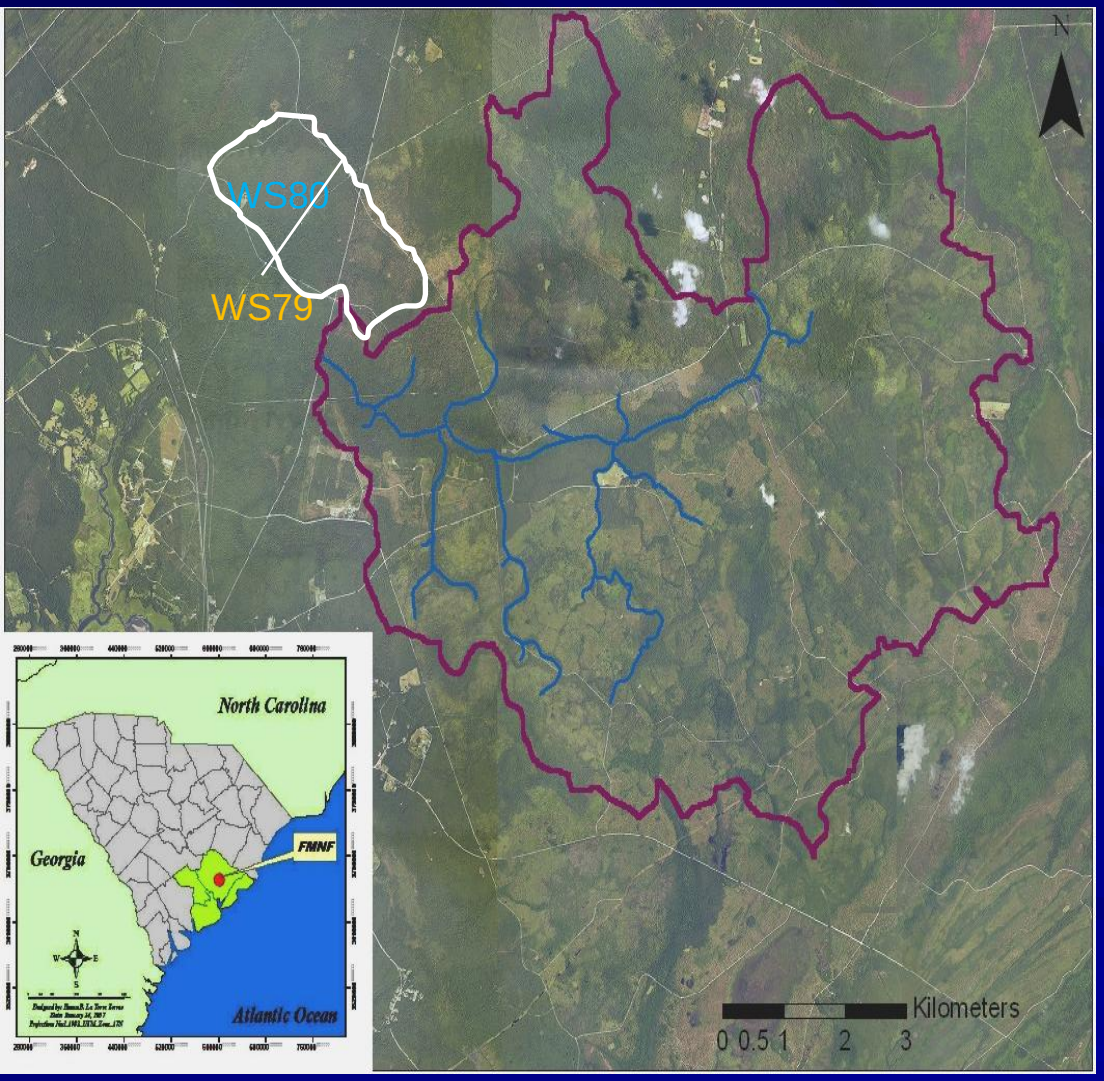
HYDROLOGIC MONITORING

- Establishment of a weather station in 1946
- 1st, 2nd & 3rd order watersheds: 1963-1968
- All monitoring discontinued in 1982
- 1st & 2nd order watersheds back in 1989 (Hugo)
- GW wells and a Full weather station: 1992-1996
- With growing concerns on water quantity/quality
- 3rd order Turkey Creek watershed was also revitalized in 2004 with the establishment of a real time gauging station by USGS/CofC/FS
- Evaluating impacts, Developing new hypotheses and models for land use/climate change, restoration, ecosystem functions/values.

GOAL & OBJECTIVE

- To build a strong multi-cooperative research partnership for a comprehensive long-term monitoring effort on this coastal forested watershed as a baseline reference system to address the critical issues of sustainable water management
- To summarize results of recent collaborative monitoring and modeling studies on hydrology and water quality

TURKEY CREEK WATERSHED

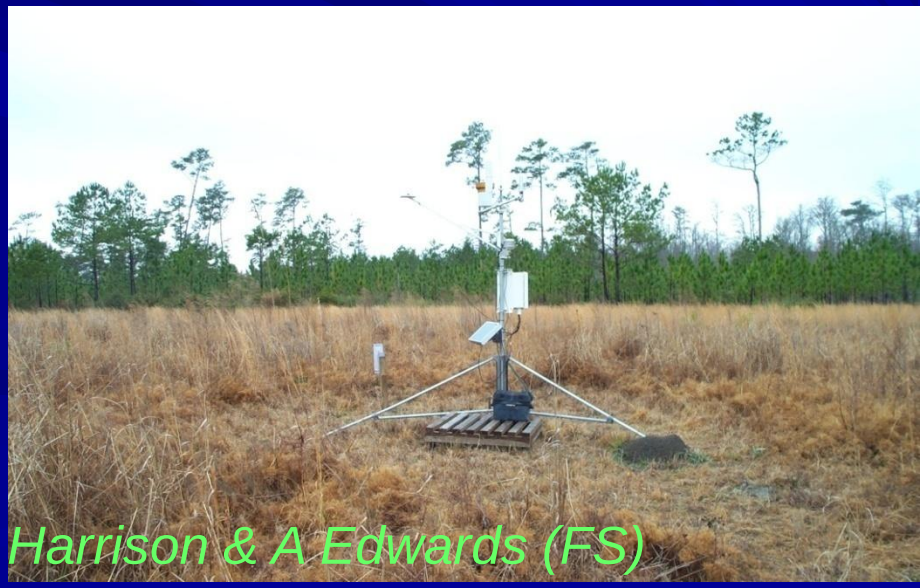


- 7,250 ha (72.5 km^2)
- Using SWAT-DEM
- FMNF, Typical of LCP
- 97% Forests
- Shallow soils
- 6.7 km^2 water/wetlands
- 3rd order stream
- 9.8 km stream length
- 3.6 m to 14 m a.m.s.l.

Pine & Hardwood Stands

Current Monitoring

- Stream flow: 2005 – (USGS, CofC)
- Rainfall: 2005 – (USGS, CofC, and FS)
- Complete weather: 2005 – (FS)
- Shallow groundwater: 2006 – (FMNF, FS)
- Deep groundwater: 2005 – (CofC)
- Water quality: 2006 – (FS)



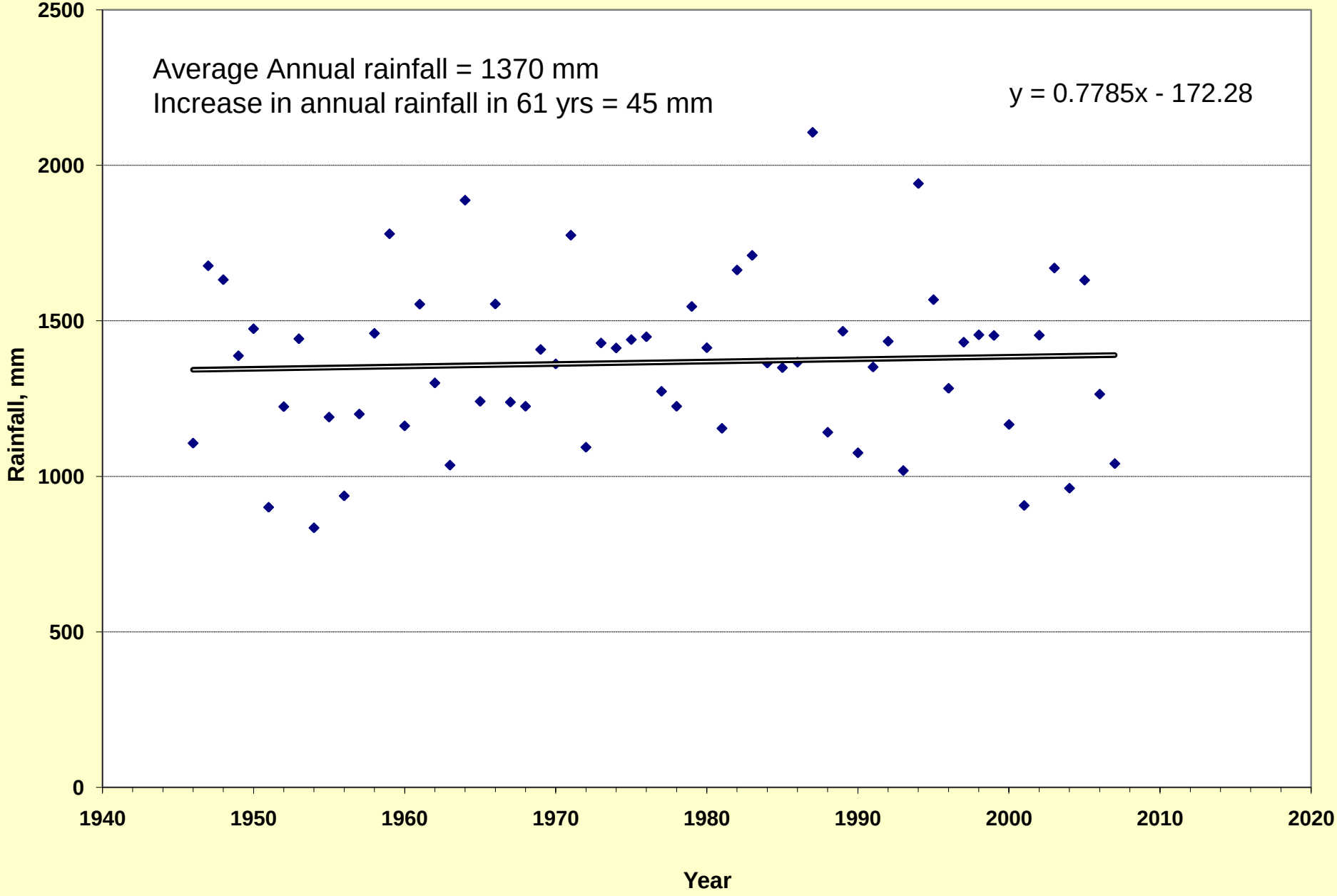
J Erbland & W Spingfield (USGS) and A Harrison & A Edwards (FS)

Spatial Data

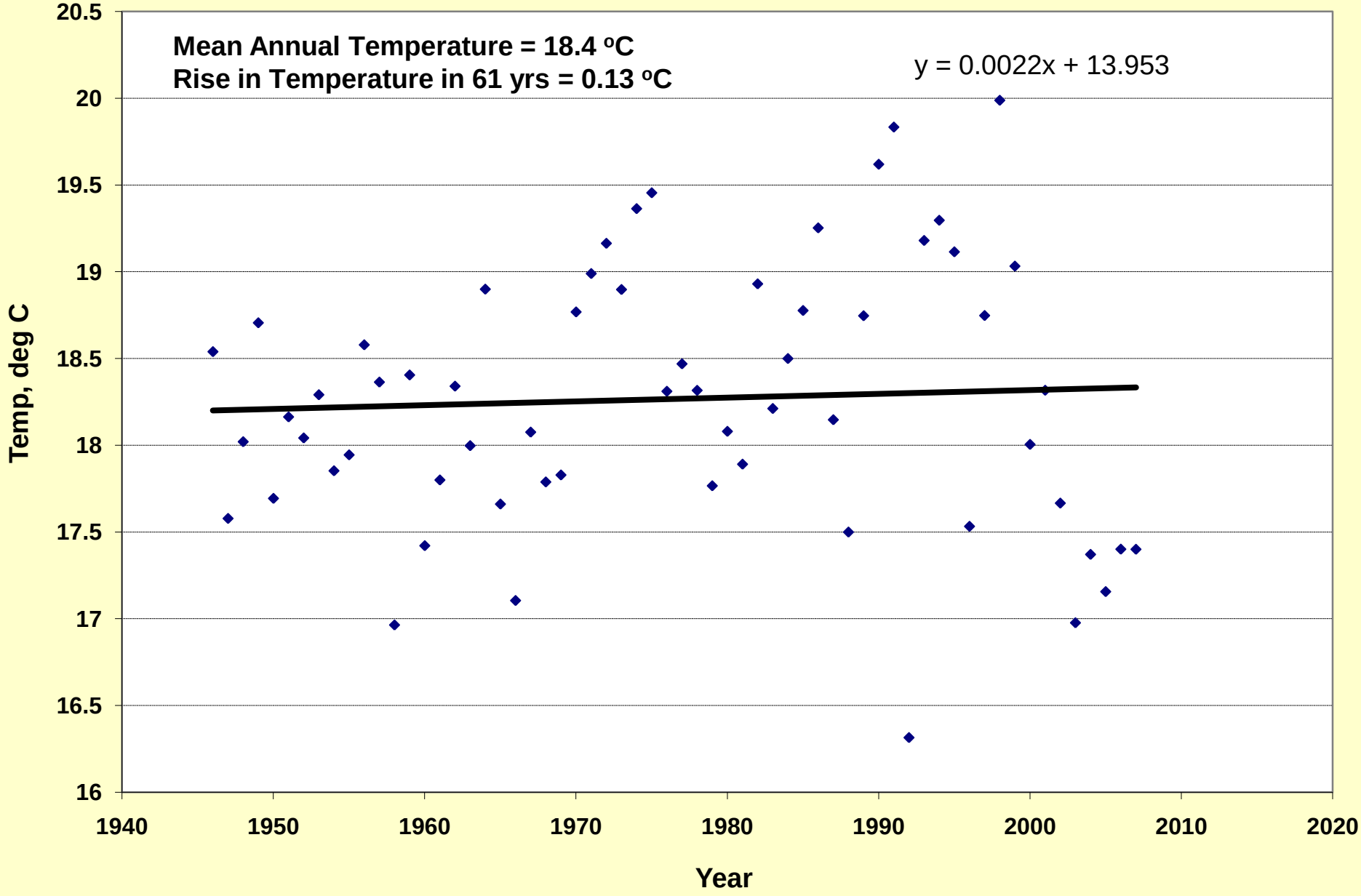
- Historic aerial photographs
- 1999 Satellite Image
- 2005 USGS DEM (10mx10m)
- 2005 NAIP Imagery
- Land use from 2005 NAIP Imagery
- NRCS SSURGO and FMNF Soil Maps

MONITORING RESULTS

Santee HQ Annual Rainfall, 1946-2007

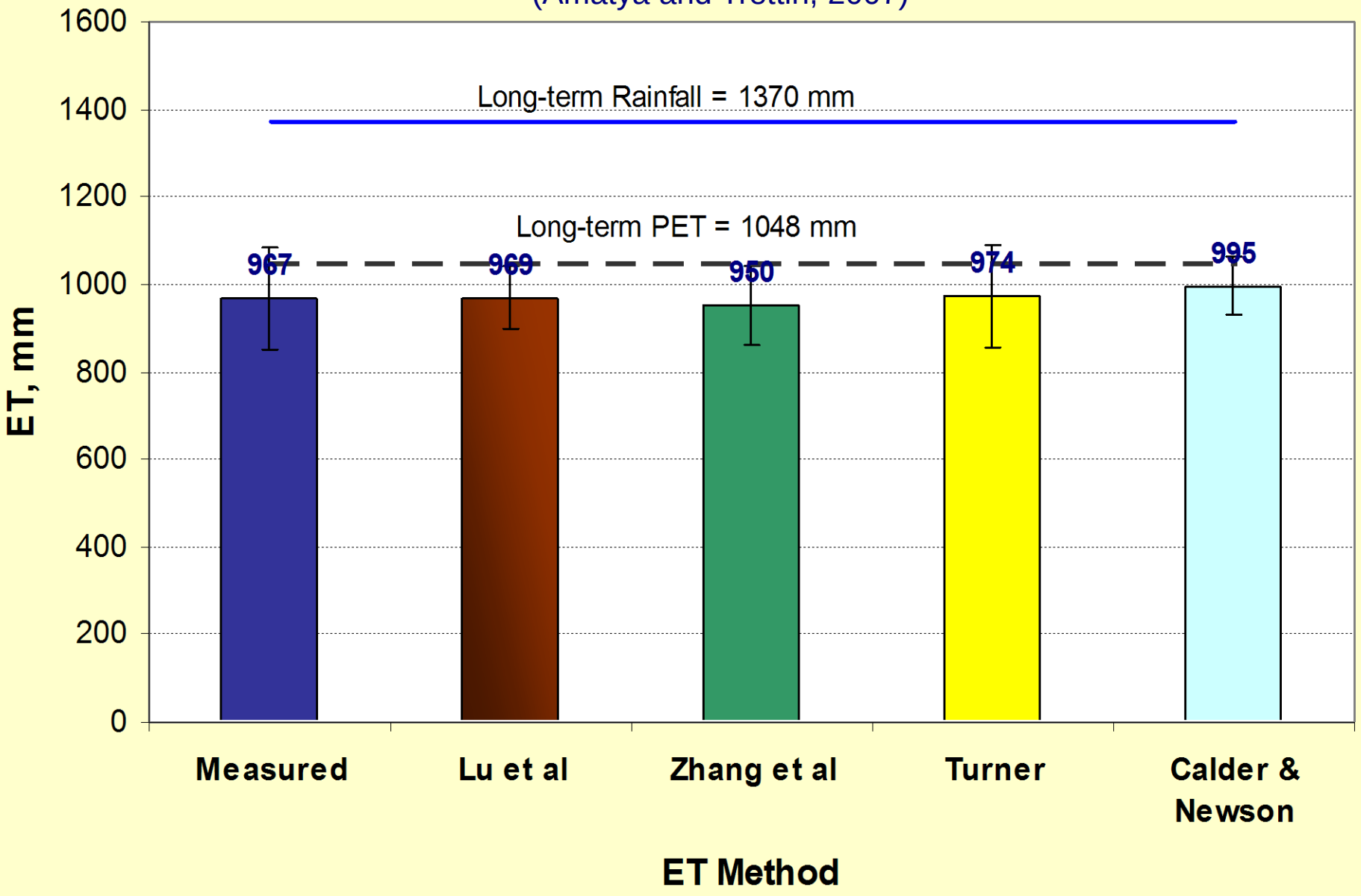


Santee HQ Annual Average Temperature, 1946-2007



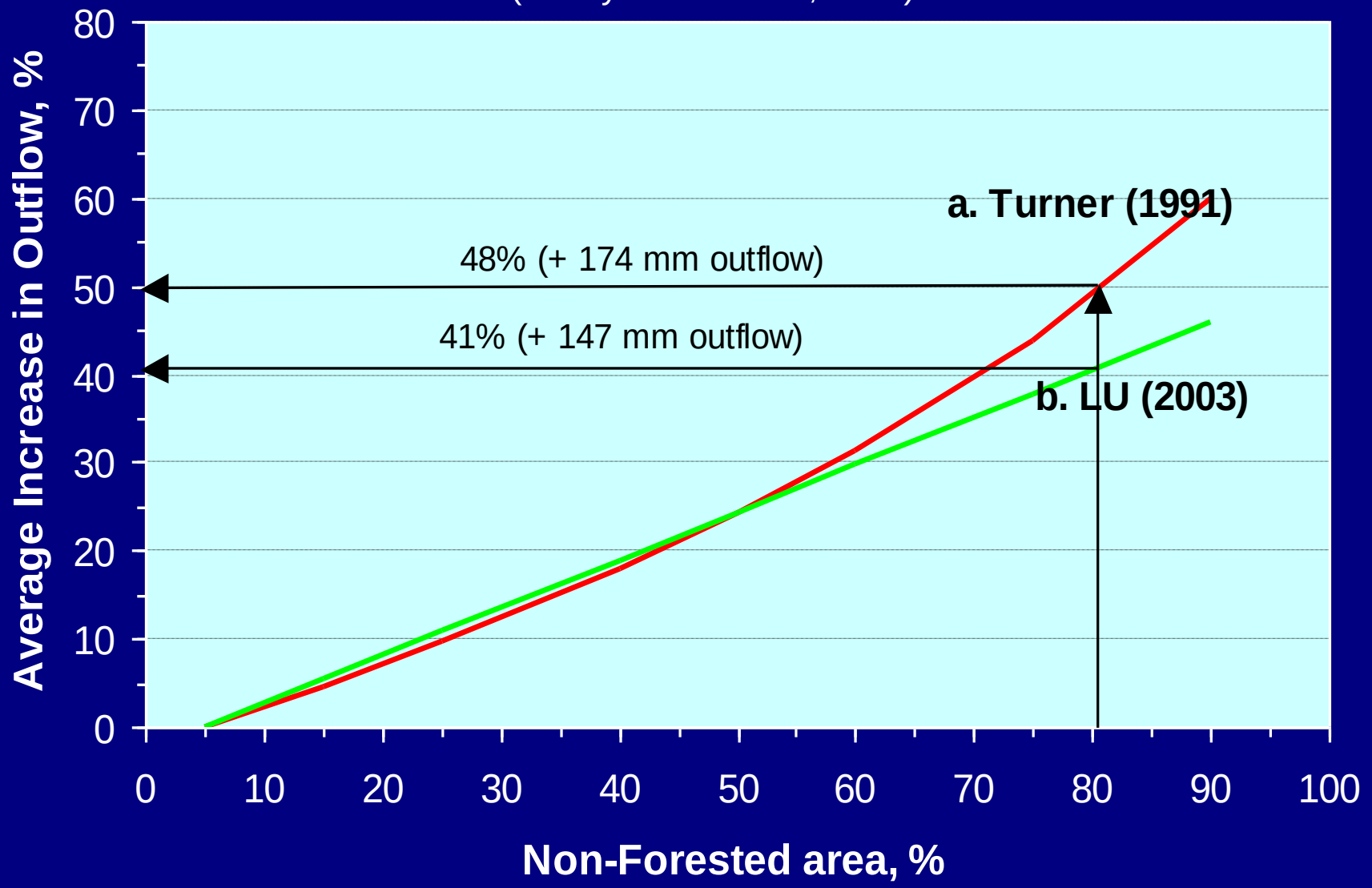
Average Annual Measured and Calculated ET, 1964-76

(Amatya and Trettin, 2007)



Increase in % Outflow vs % Forest Removal

(Amatya and Trettin, 2007)

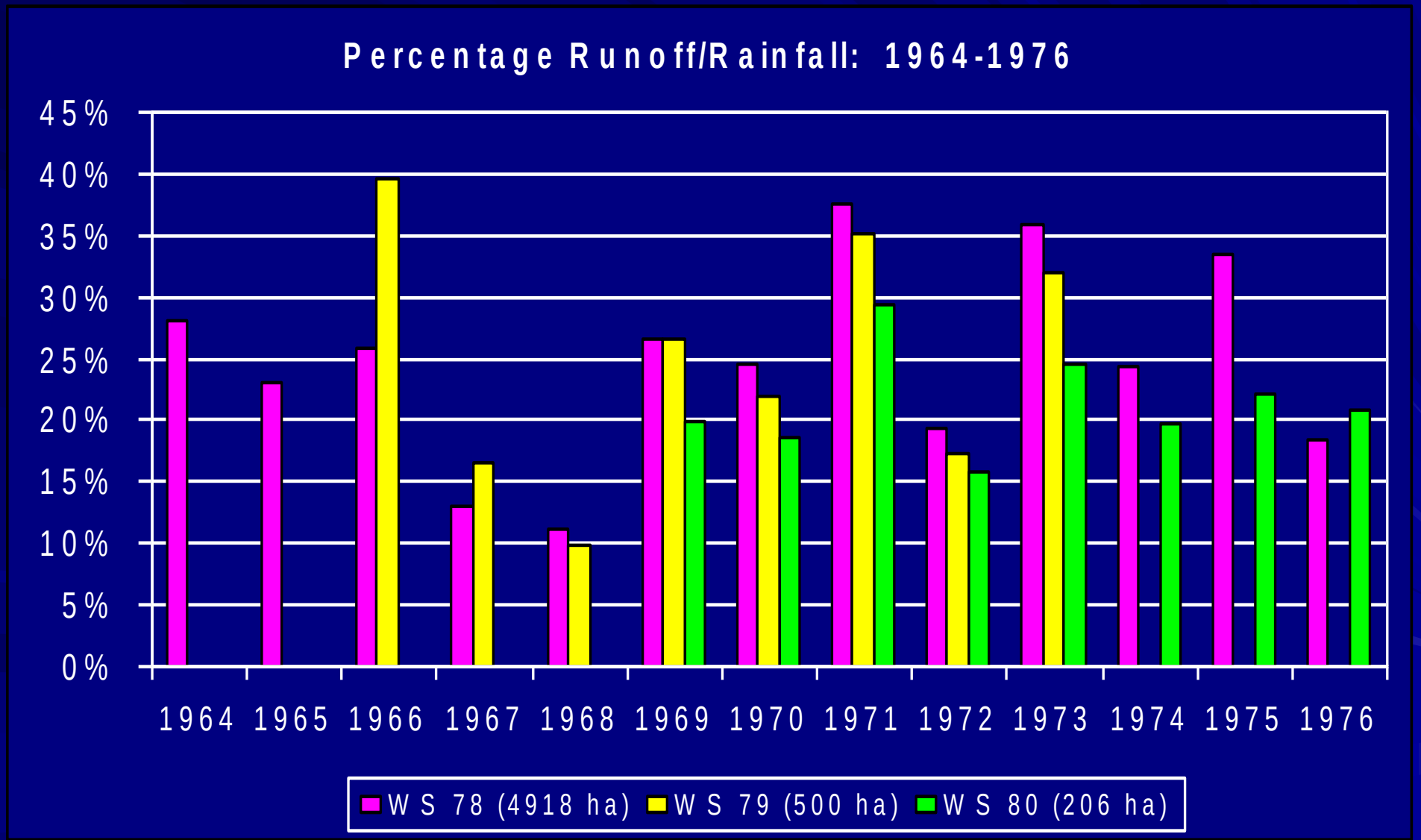


Average Annual Water Balance

- Rainfall = 1320 mm (1964-76); 898 mm (2007); 1851 mm (1964)
- Temperature = 18.4 ^{o}C
- Potential ET = 1050 mm
- Actual ET = ~ 970 mm
- Water Yield = 336 mm = 24 x10^{6} cu.m.
- R/O Coefficient = 25%
- *Ground water = ????*

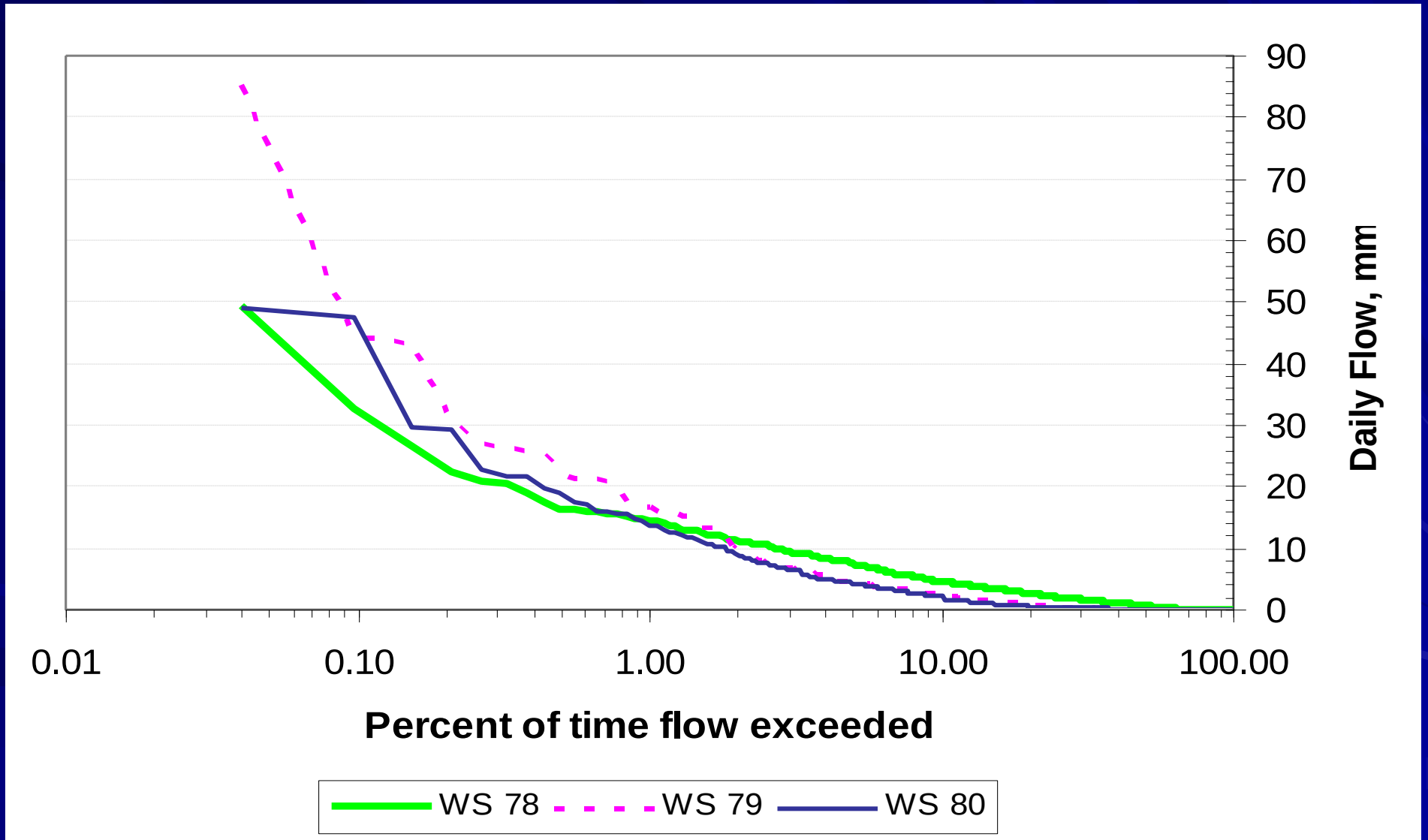
Comparison of Runoff

(Amatya and Radecki-Pawlik, 2007)



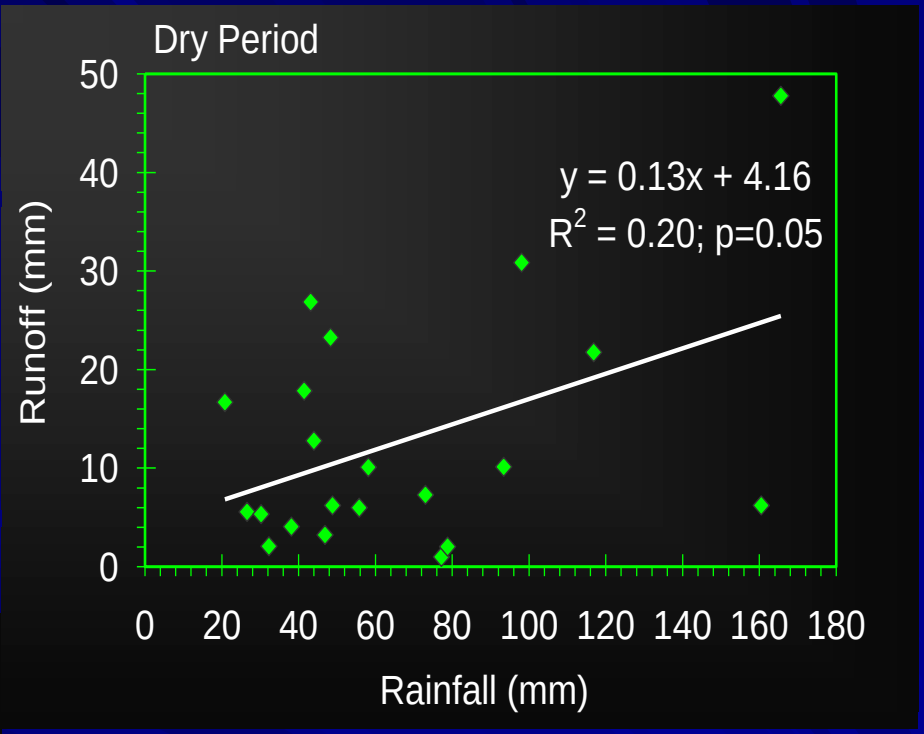
Comparison of Flow Duration Data

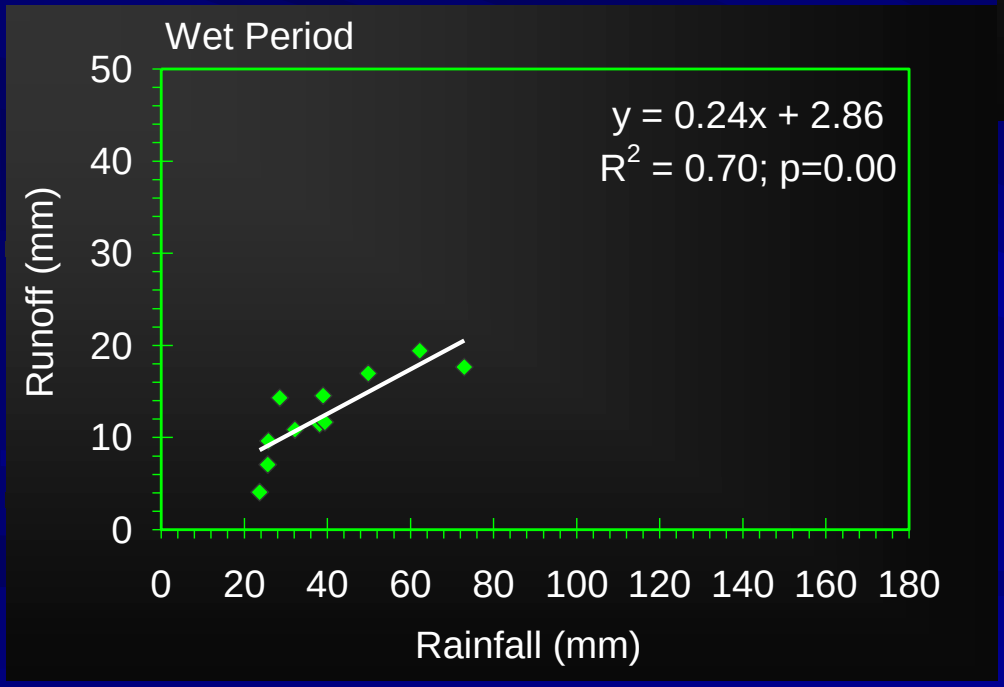
(Amatya and Radecki-Pawlik, 2007)



Seasonal Rainfall-Runoff Relationships

(La Torres, 2008; SC Sea Grant)





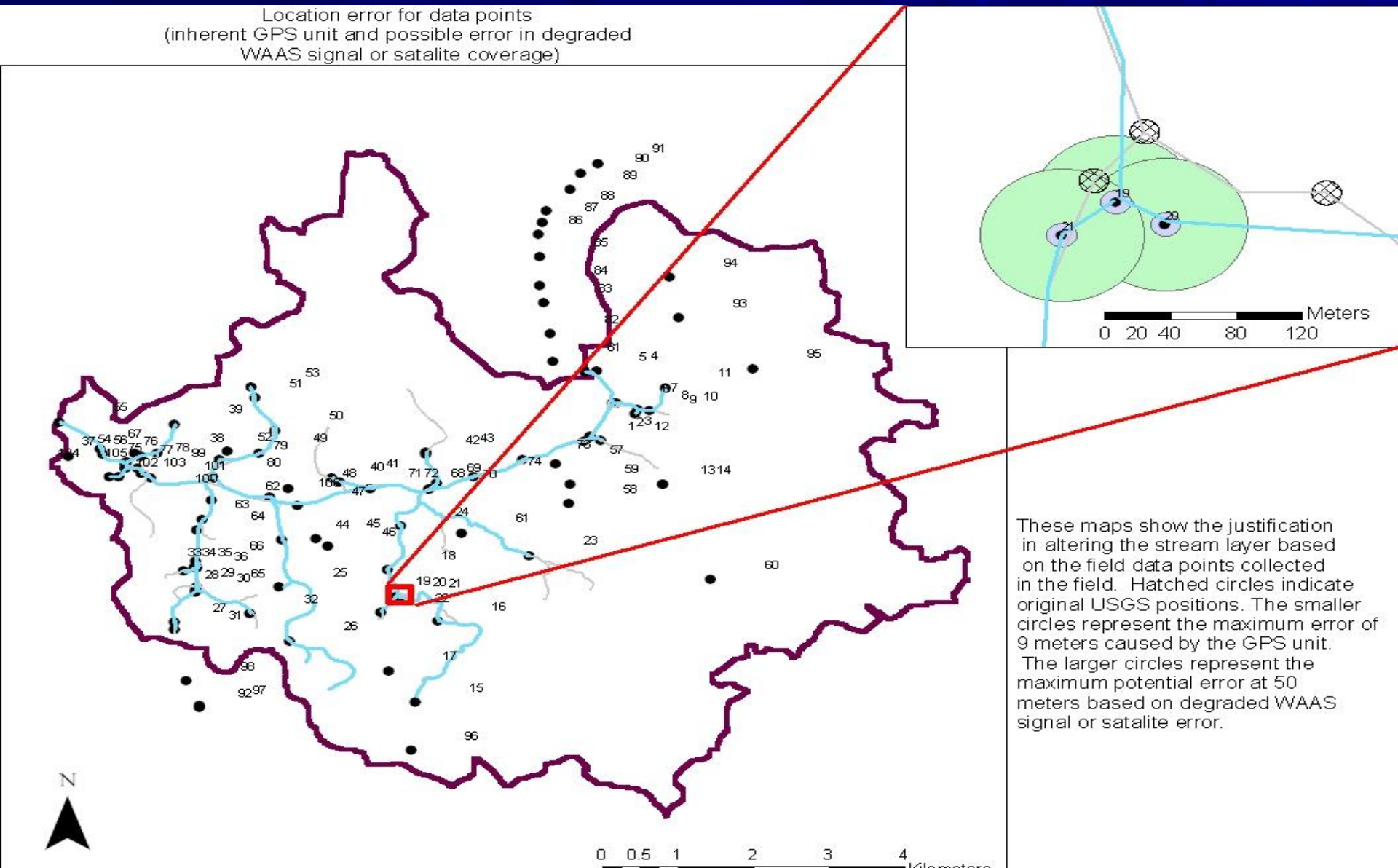
Very much dependent upon antecedent moisture conditions

Tributaries, Road Crossings and Water Features

(Haley, 2007)

Stream Field Mapping

(Haley, 2007)



These maps show the justification in altering the stream layer based on the field data points collected in the field. Hatched circles indicate original USGS positions. The smaller circles represent the maximum error of 9 meters caused by the GPS unit. The larger circles represent the maximum potential error at 50 meters based on degraded WAAS signal or satalite error.

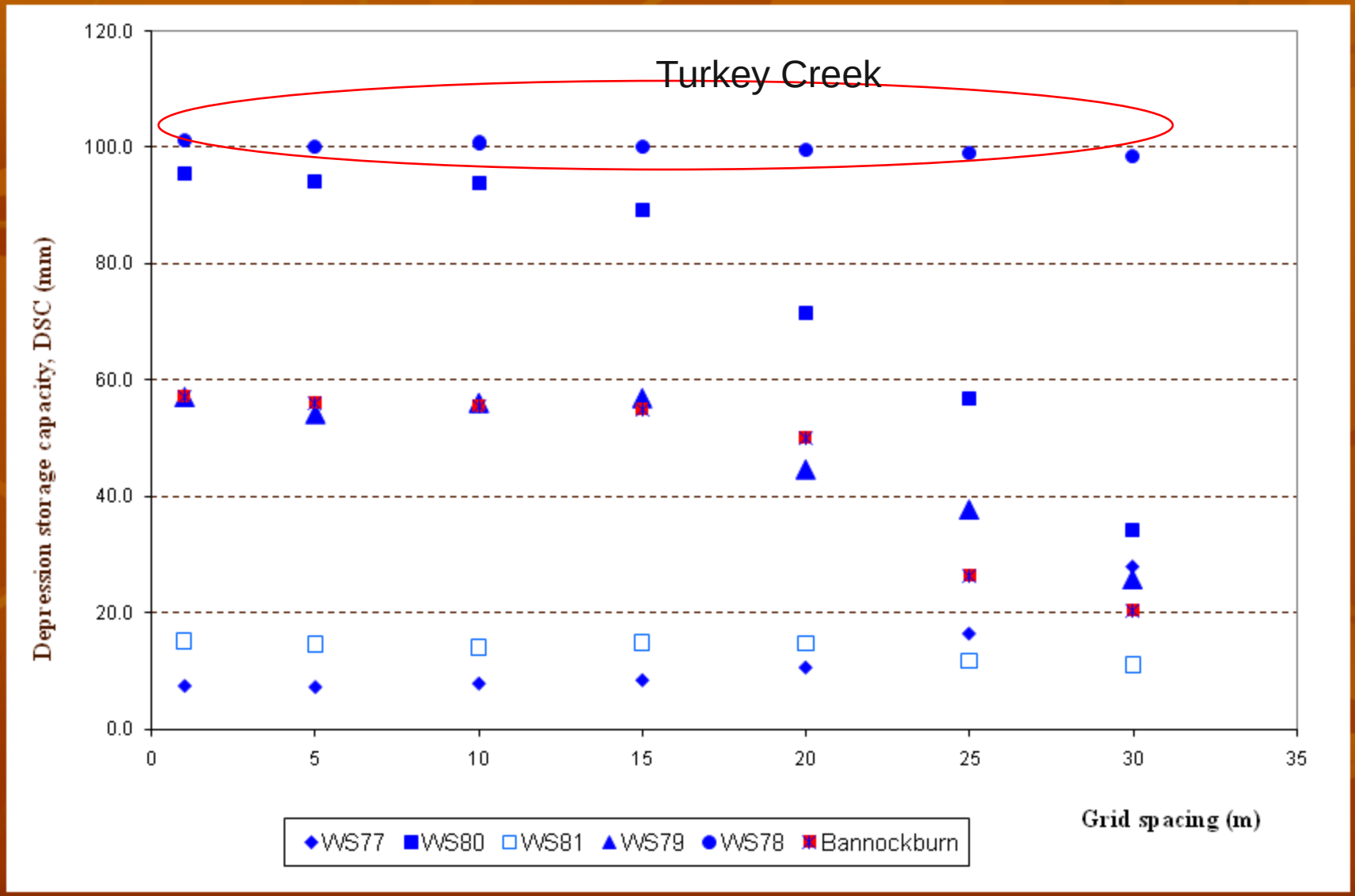
Hydraulics of Culverts & Bridges

(Radecki-Pawlik et al 2008)

Point	Name	Type/Amount	Width or Diameter f/ m	Height f/ m	Length f/ m	Condition	Discharge cfs/ cms
4	Culvert	Metal/1	2.75/ 0.84		37/ 11.25	Good	21.54/ 0.61
13	Culvert	Metal/1	1.50/ 0.46		27/ 8.21	Good	3.53/ 0.10
17	Culvert	Concrete/1	1.50/ 0.46		28.5/ 8.66	Good	4.24/ 0.12
18	Culvert	Metal/1	2.83/ 0.86		12/ 3.64	Poor	22.60/ 0.64
24	Culvert	Metal/1	2/ 0.61		30/ 9.12	Good	8.12/ 0.23
25	Culvert	Metal/1	0.83/ 0.25		27/ 8.21	Poor	0.71/ 0.02
37	Culvert	Concrete/1	1/ 0.30		21/ 6.38	Poor	1.06/ 0.03
38	Culvert	Metal/2	2/ 0.61		31/ 9.42	1 good/ 1 poor	9.89/ 0.28
40	Culvert	Concrete/1	3.25/ 0.99		33/ 10.03	Good	39.55/ 1.12
42	Culvert	Concrete/1	1.58/ 0.48		28/ 8.51	Good but beginning to degrade	4.59/ 0.13
44	Culvert	Concrete/1	2.5/ 0.76		33/ 10.03	Poor- filled in with debris	18.36/ 0.52
45	Culvert	Metal/1	1.25/ 0.38		22/ 6.67	Fair-partially bent	2.12/ 0.06
47	Culvert	Metal/1	1.5/ 0.46		23/ 6.99	Poor	3.53/ 0.10
48	Culvert	Concrete/1	4/ 1.22		41/ 12.46	Good	55.08/ 1.56
49	Culvert	Metal/1	2.5/ 0.76		35/ 10.64	Good	15.54/ 0.44
51	Culvert	Concrete/1	1.33/ 0.40		23/ 6.99	Poor	2.82/ 0.08
53	Culvert	Concrete/1	1.67/ 0.51		28/ 8.51	Good	6.00/ 0.17
54	Culvert	Concrete/1	1.25/ 0.38		20/ 6.08	Good	3.50/ 0.01

Relationship between DSC DEM Grid Spacing

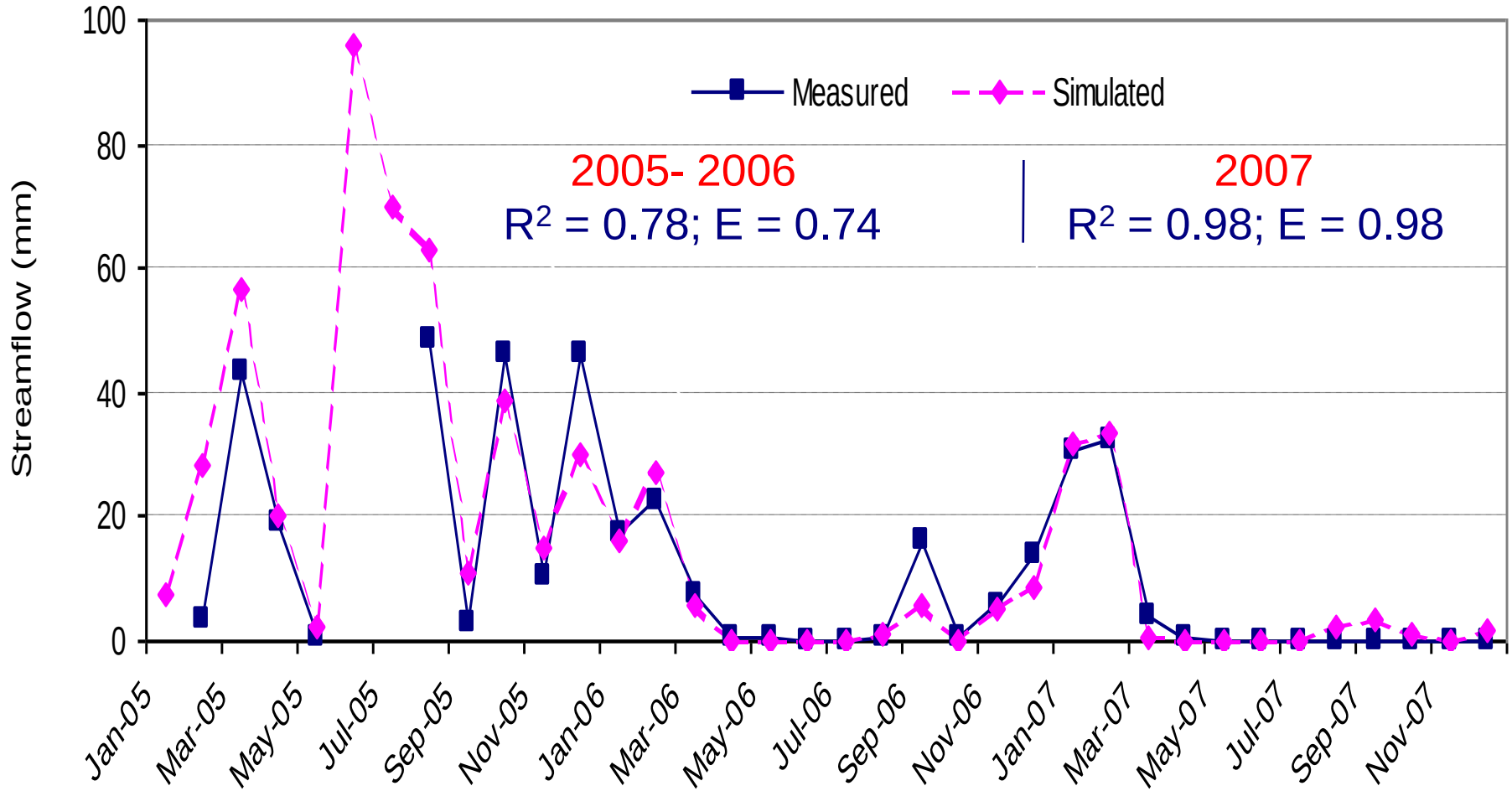
(Amoah, 2008)



MODELING RESULTS using SWAT (Soil & Water Assessment Tool, USD ARS)

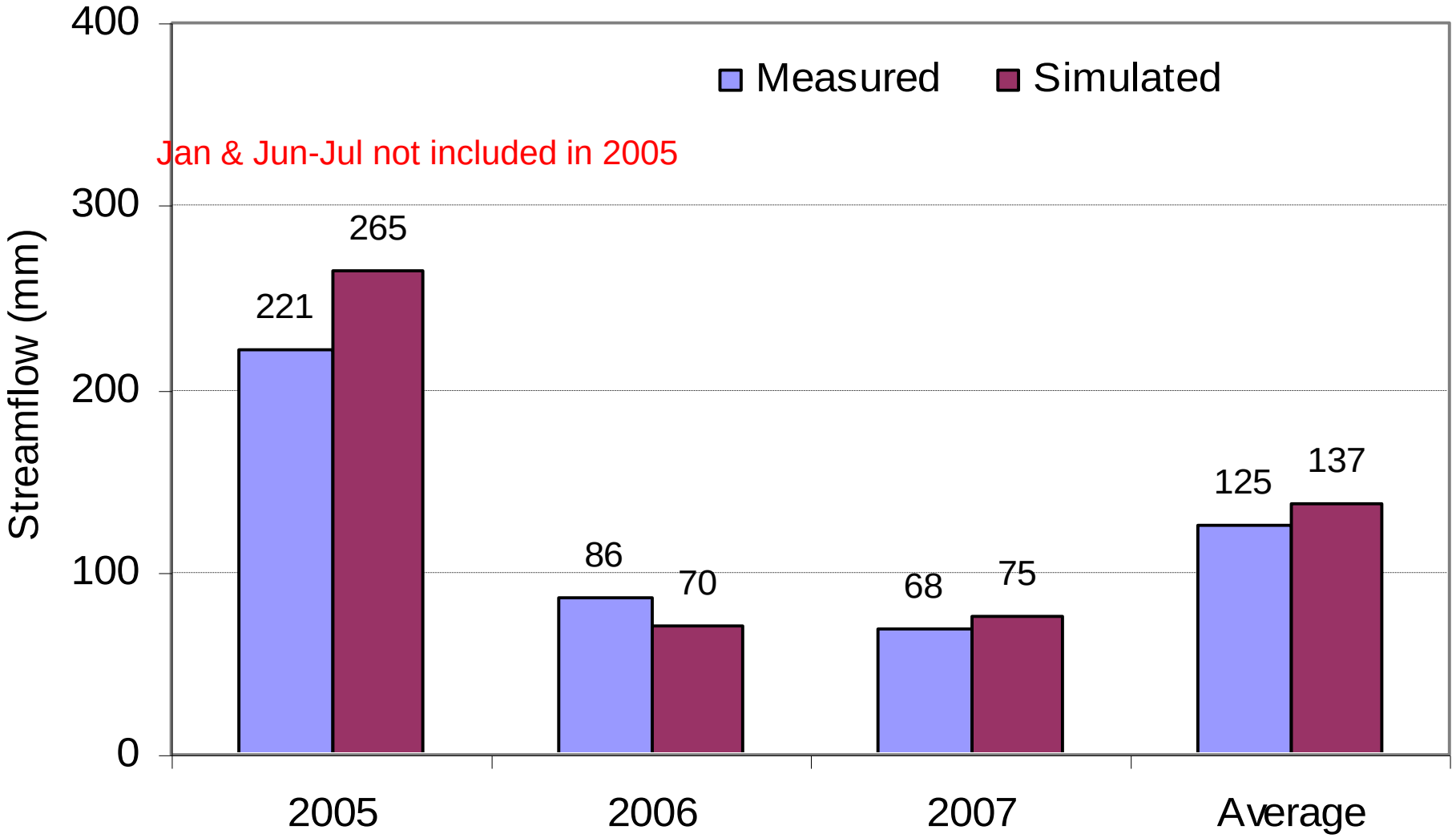
Measured/Predicted Monthly Outflows – 2005-06 (Calibration) & 2007 (Validation)

(Amatya et al, 2008)

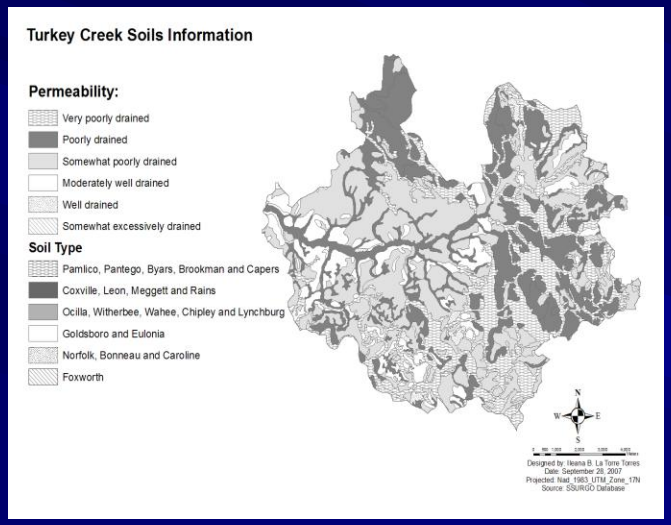


Measured & SWAT Predicted Annual Streamflow for 2005-07

(Amatya et al, 2008)

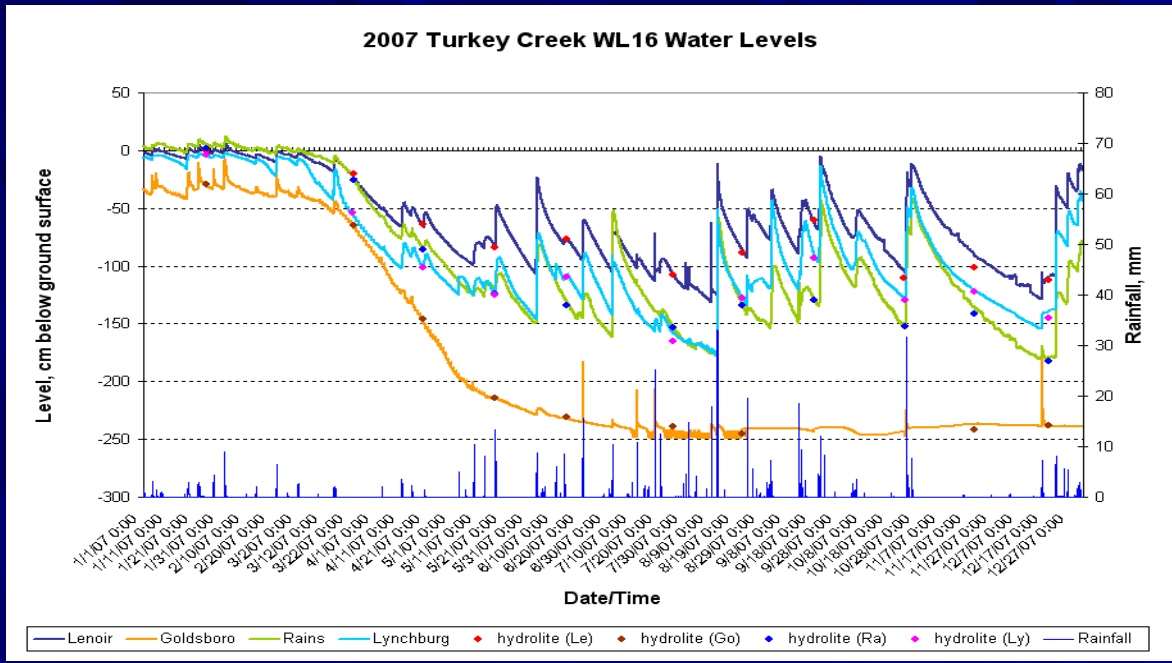


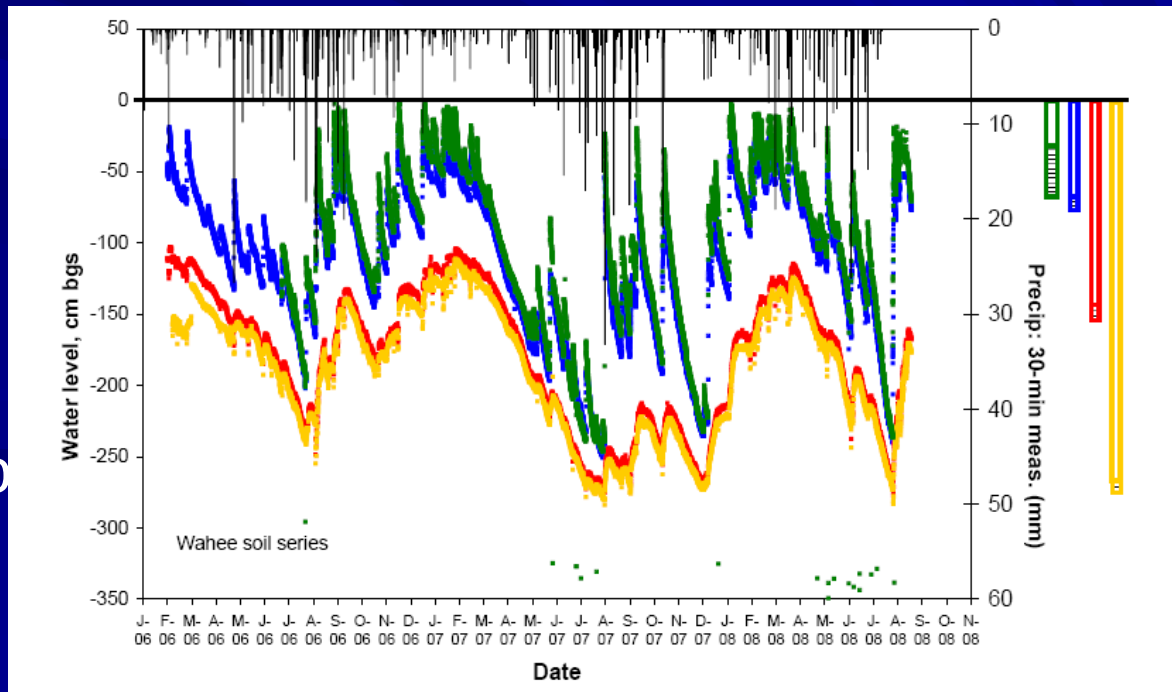
WATER TABLE MONITORING (2006-08)



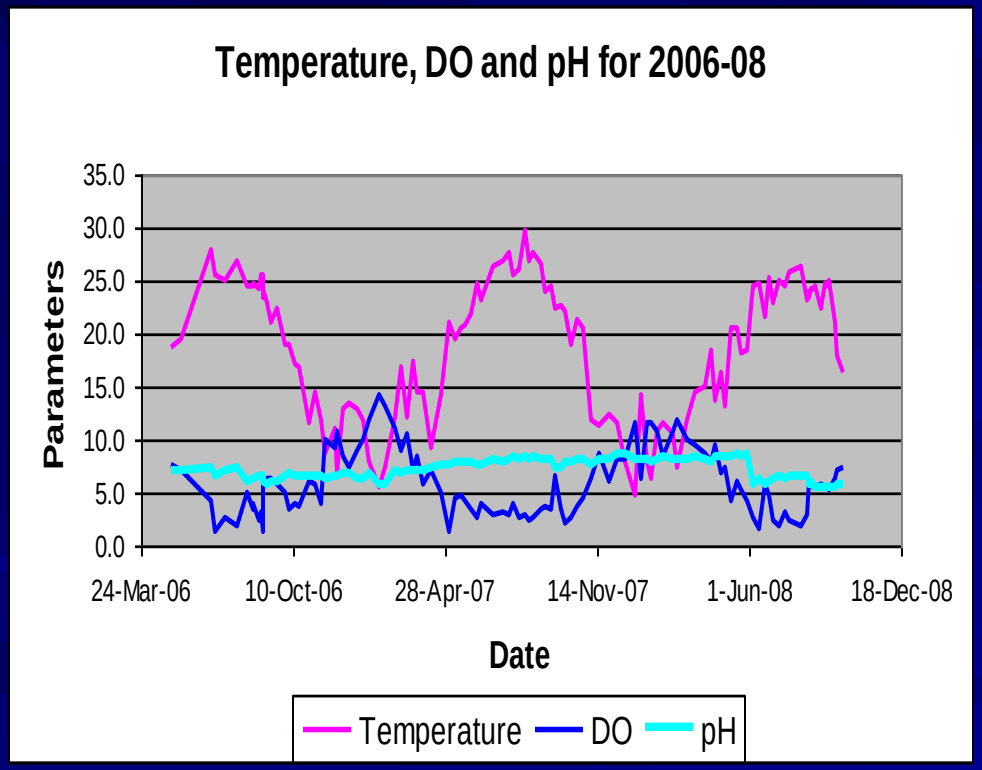
Ongoing Surface-subsurface water Interactio study

CofC scientists & Grads

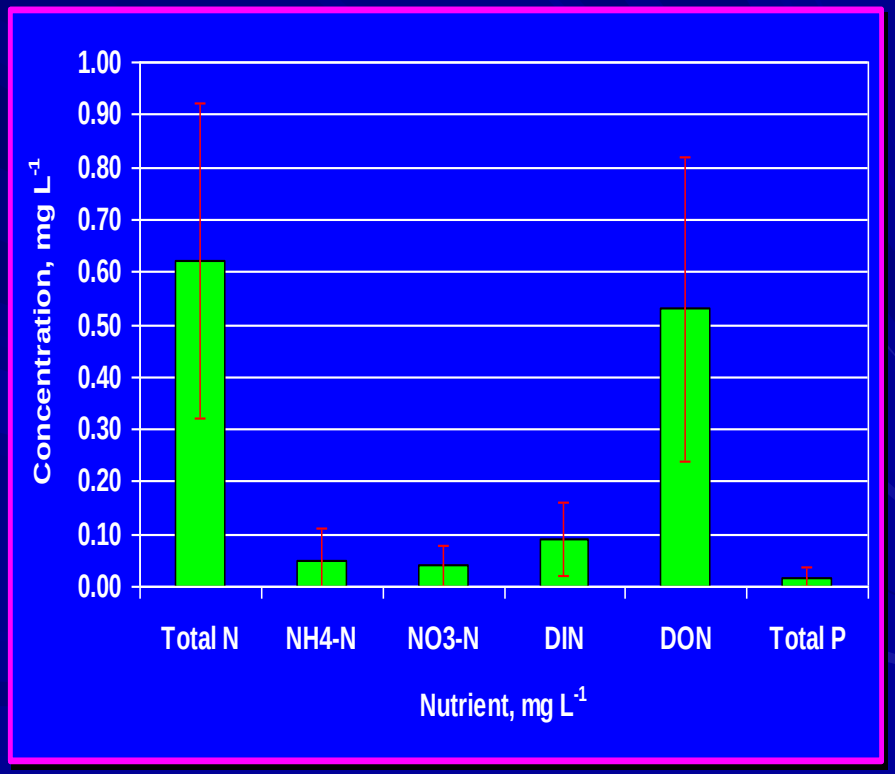




Physical Parameters
Apr 06 – Oct 08



NUTRIENT CONCENTRATIONS
Nov 05 – May 07 (Needs updates)



SUMMARY

- Historic (1964-76) and current data since 2005 – A baseline information on hydrology and water quality of a typical lower coastal plain watershed.
- Stream flow dynamics, Rainfall-runoff relationships & mechanisms, water balance components and water quality were described for the forest reference system.
- SWAT hydrologic model was successfully calibrated for predicting daily and monthly flows.
- These hydrologic/water quality data together with the calibrated model SWAT can be useful for evaluating impacts of development, urbanization, land use and climate change and extreme events.
- Site and Data are available for sharing with cooperators and partners

NEXT STEPS

- Expand/Strengthen collaborative efforts
- Obtain LIDAR data for accurate assessments
- Expand additional monitoring e.g. nested catchments, WQ parameters like Hg, coliform bacteria, sediment etc.
- Study surface-subsurface water interaction
- Study runoff generation mechanism
- Evaluate scenarios of land use and climate change using SWAT model

COOPERATORS

- FS Southern Research Station
- National Council for Air & Stream Improvement, Inc.
- FS Francis Marion National Forest
- US Geological Survey
- College of Charleston
- JJ&G Company/ Tetra-Tech, Inc.
- SC Department of Transportation
- University of Krakow, Poland
- Florida A& M University
- SC Sea Grants Program
- Clemson University

THANK YOU !!!